

Recycling Rate of Atmospheric Moisture Over the Past Two Decades (1988-2009)

Xun Jiang¹, Liming Li¹, Moustafa Chahine², Edward Olsen², Eric Fetzer², Luke Chen², and Yuk Yung³

¹ Department of Earth & Atmospheric Sciences, Univ. of Houston

² Science Division, Jet Propulsion Laboratory, Caltech

³ Division of Geological & Planetary Sciences, Caltech

NASA Sounder Science Team Meeting, Nov 8-11, 2011

Li, L., X. Jiang, M. Chahine, E. Olsen, E. Fetzer, L. Chen, and Y. Yung, 2011: Recycling rate of atmospheric moisture over the past two decades (1988-2009), Environmental Research Letters, doi: 10.1088/1748-9326/6/3/034017.

Overview

- **Motivation**
- **Data**
- **Variations in Precipitation, Water Vapor, and Recycling Rate**
- **Conclusions**

Motivation

- The recycling rate of atmospheric moisture is an important index of the climate change.
- Spatial patterns of temporal variations in precipitation, water vapor, and recycling rate will be helpful to understand the hydrological cycle as a response to the global warming, and provide constraints for the climate models.

Data

I) Precipitation

1. Global Precipitation Climatology Project (GPCP) V2.1 -- Global

Spatial: $2.5^{\circ} \times 2.5^{\circ}$; Temporal: 1979-2009

2. Special Sensor Microwave Imager (SSM/I) V6 -- Ocean

Spatial: $0.25^{\circ} \times 0.25^{\circ}$; Temporal: 1988-present

II) Water Vapor

1. SSM/I V6 -- Ocean

Spatial: $0.25^{\circ} \times 0.25^{\circ}$; Temporal: 1988-present

2. Atmospheric Infrared Sounder (AIRS; Global) and Advanced

Microwave Scanning Radiometer (AMSR; Ocean) V5

Spatial: $1^{\circ} \times 1^{\circ}$; Temporal: 2002-present

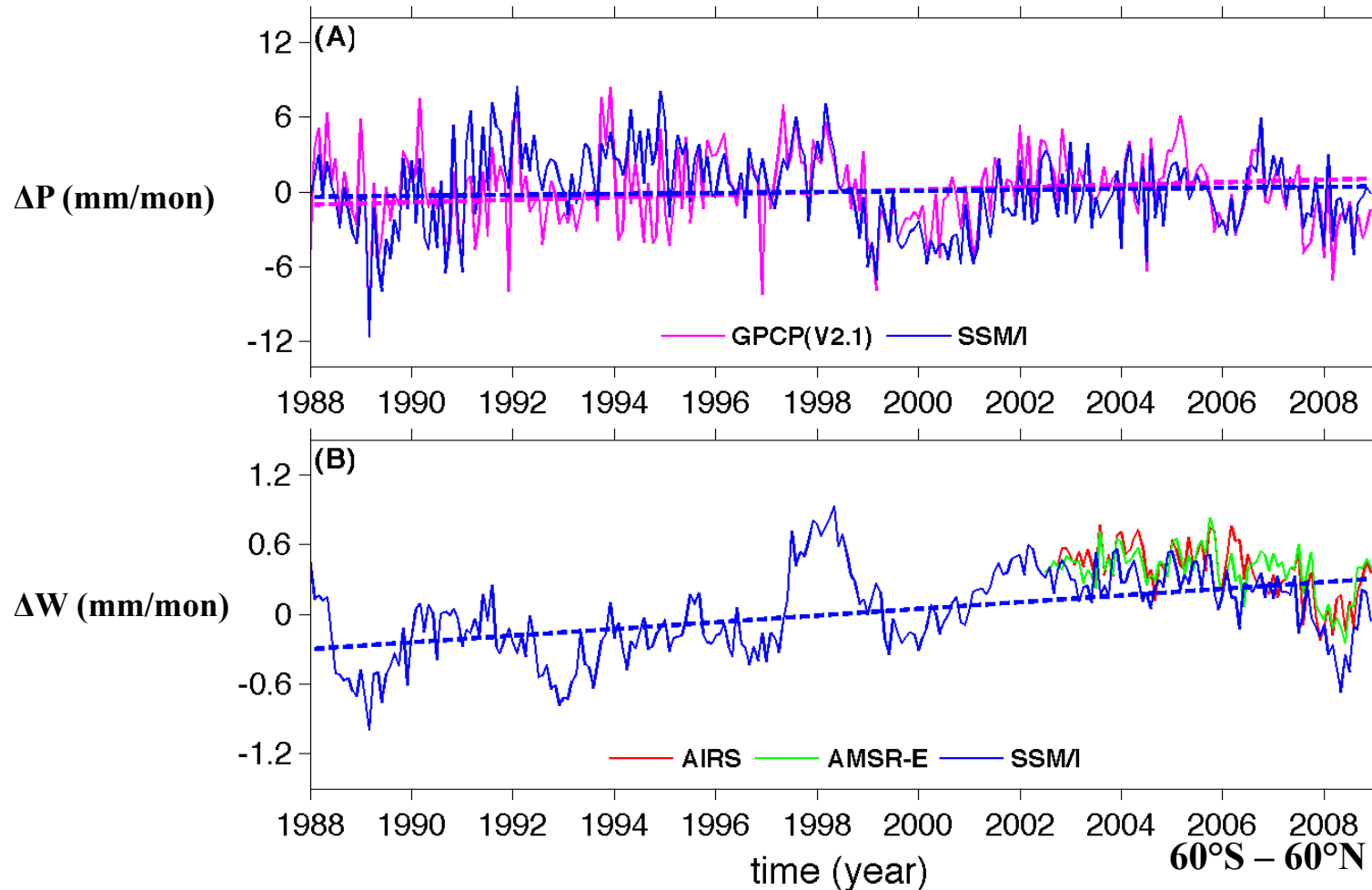
Recycling Rate

$$\text{Recycling Rate} = \frac{\text{Total Monthly Precipitation}}{\text{Mean Precipitable Water Vapor}}$$

[Chahine *et al.*, 1997]

Precipitation and Water Vapor

Ocean



(A) Deseasonalized time series of oceanic precipitation from GPCP V2.1 and SSM/I.

(B) Deseasonalized time series of oceanic water vapor from SSM/I, AIRS, and AMSR-E.

Variations in Recycling Rate, Precipitation, and Water Vapor

Recycling rate (R) is defined as the ratio between precipitation (P) and column water vapor (W).

$$R = P / W \quad (1)$$

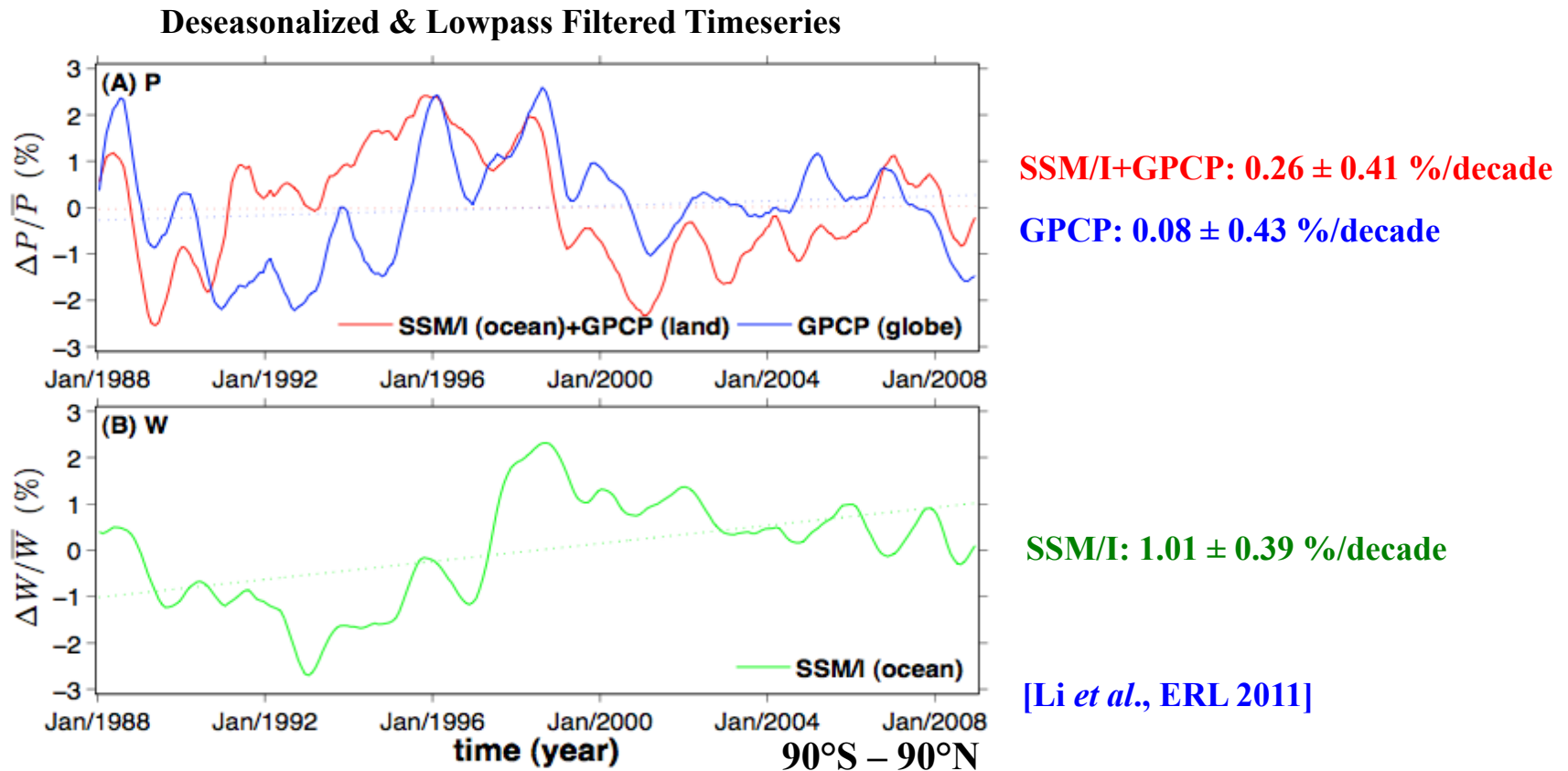
So we have

$$\begin{aligned} \ln R &= \ln(P / W) \\ \Rightarrow d(\ln R) / dt &= d[\ln P - \ln W] / dt \\ \Rightarrow (dR / dt) / R &= (dP / dt) / P - (dW / dt) / W \end{aligned} \quad (2)$$

Therefore, during a time period we can approximate Eq. (2) as bellow

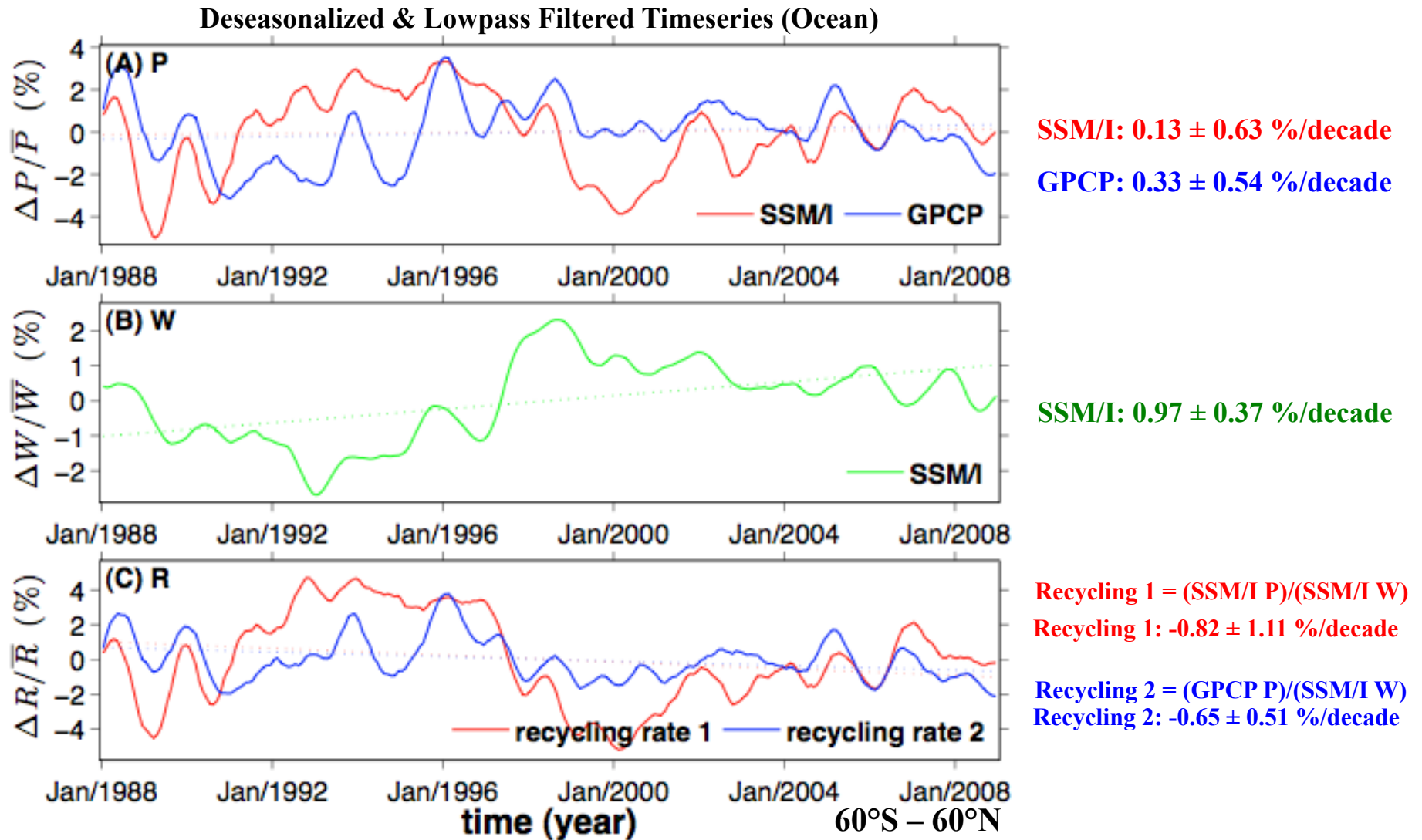
$$\Delta R / \bar{R} = \Delta P / \bar{P} - \Delta W / \bar{W} \quad (3)$$

Trends in Precipitation and Water Vapor



Weak linear trend in precipitation is much smaller than the linear trend ($1.4 \pm 0.5\%$ per decade) in the previous study (Wentz et al., 2007).

Trends in Oceanic Precipitation, Water Vapor, and Recycling Rates

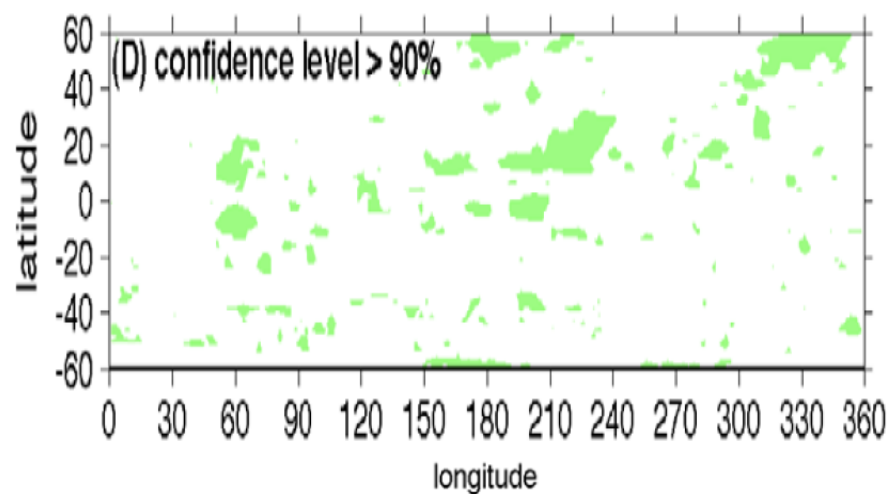
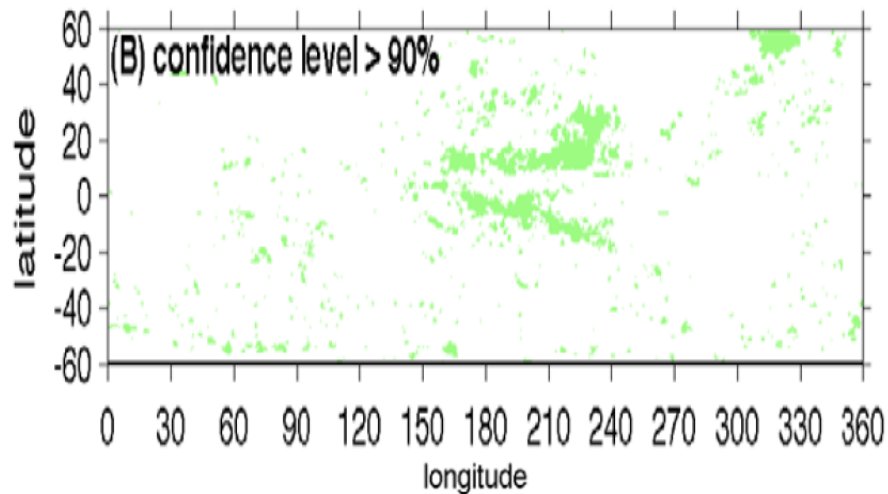
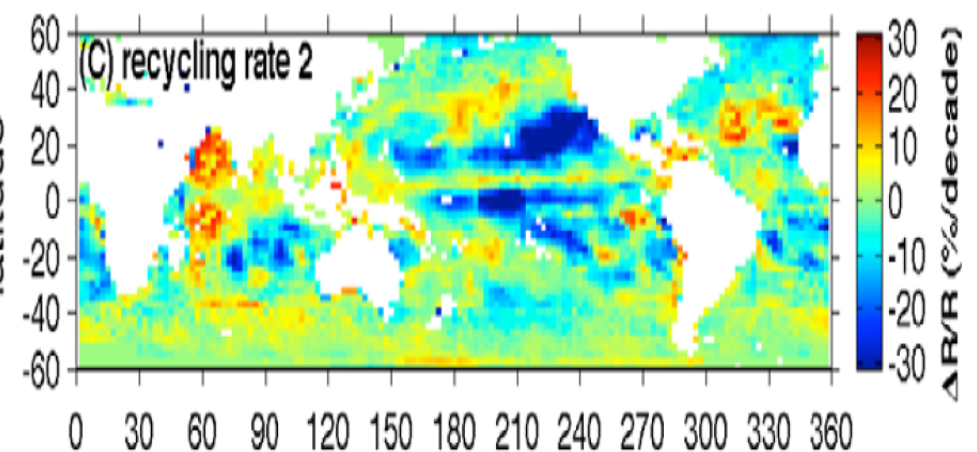
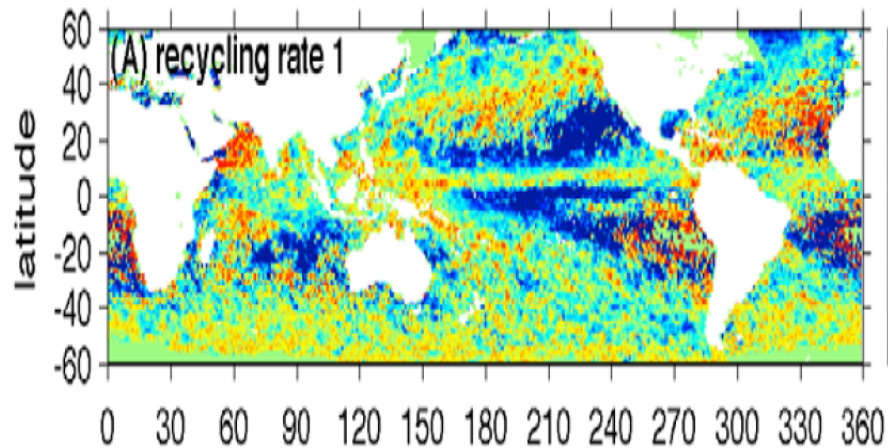


ENSO Signals have been removed by a multiple regression method.

Trend in Recycling Rate

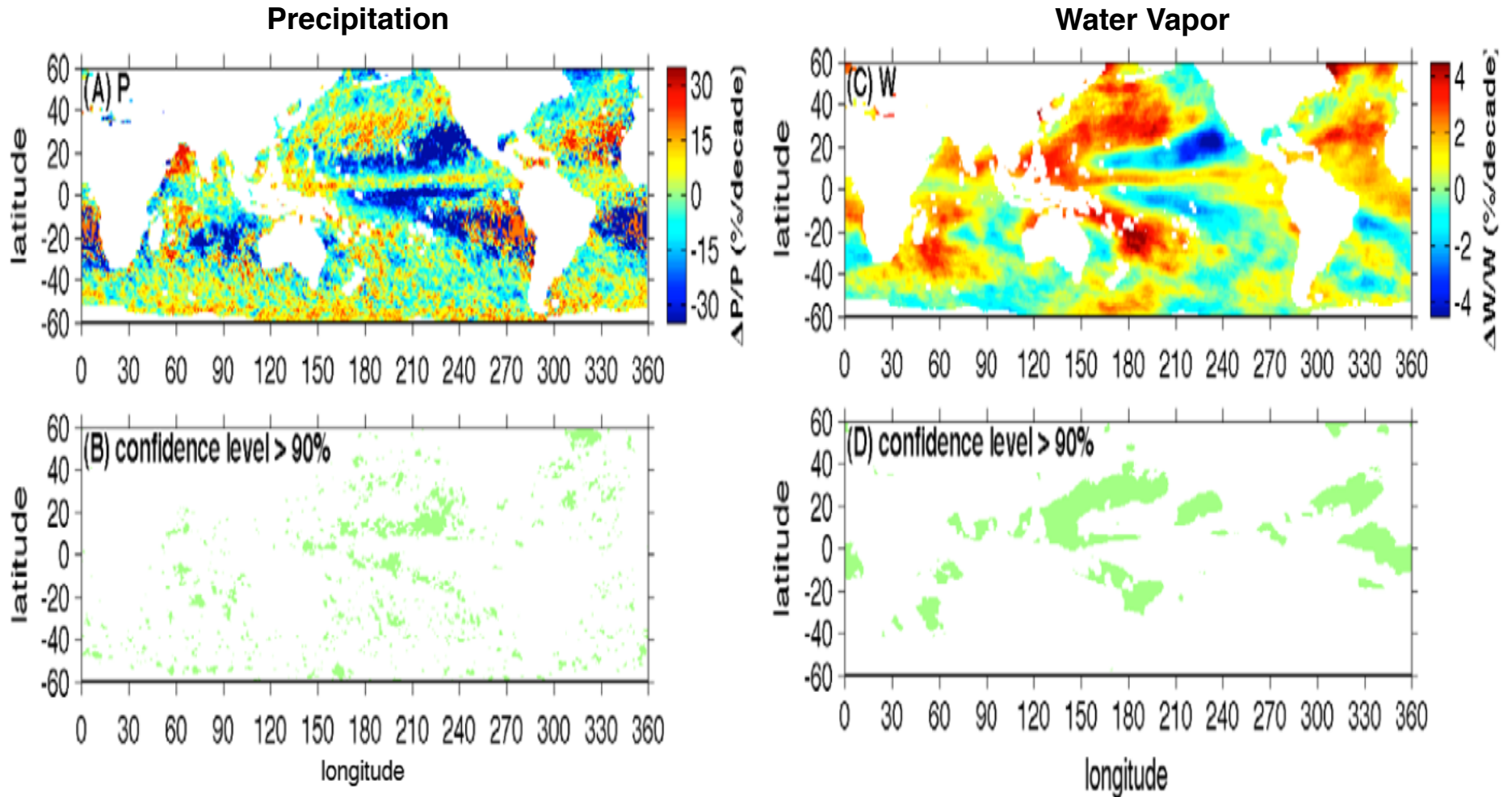
Recycling Rate1 = (SSM/I Precipitation)/(SSM/I H₂O)

Recycling Rate2 = (GPCP Precipitation)/(SSM/I H₂O)



Recycling Rate of atmospheric moisture has intensified in the ITCZ and weakened in the nearby areas.

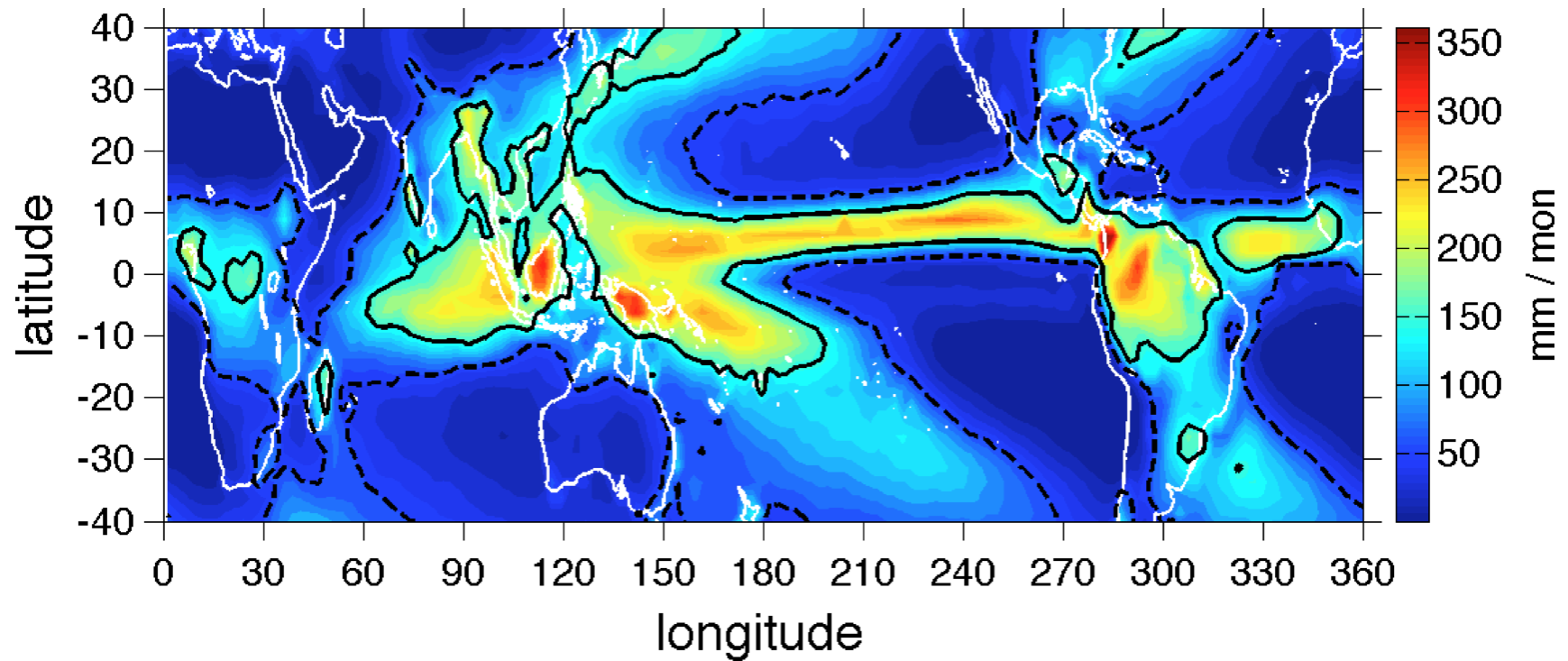
Trends in Precipitation and Water Vapor



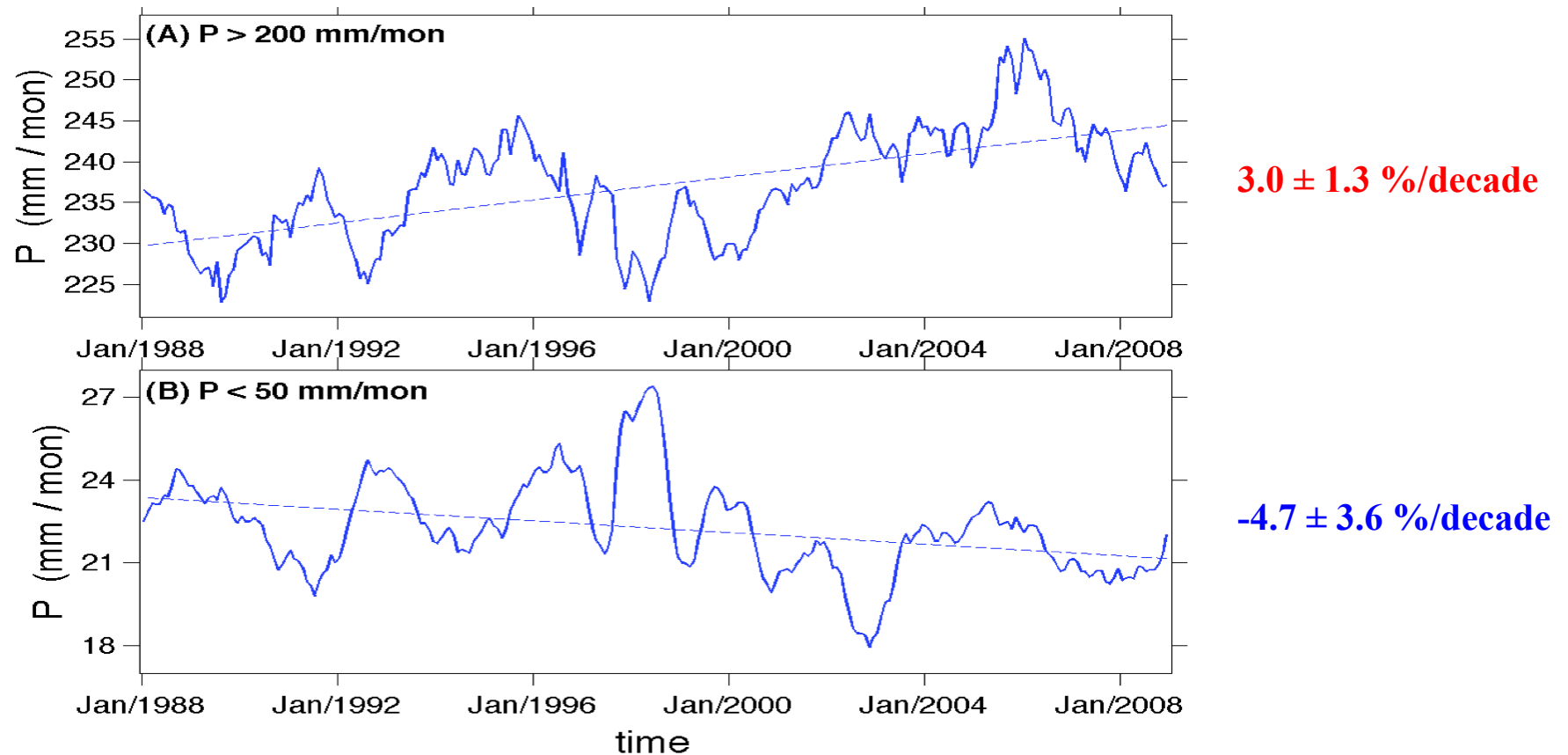
Precipitation has increased (decreased) in the high (low) precipitation areas.

Magnitude of temporal variations is stronger in the precipitation than in the water vapor.

Spatial Pattern of the Mean Precipitation for 1988-2008



Temporal Variations of Precipitation over High & Low Precipitation Areas



ENSO Signals have been removed by a multiple regression method.

Conclusions

- 1) The oceanic recycling rate of atmospheric moisture has decreased over the past two decades. Trend in the oceanic precipitation is smaller than the trend in the oceanic water vapor. AIRS global water vapor data can help better explore the global recycling rate in the future.
- 2) Recycling rate has increased in the ITCZ and decreased in the neighboring regions over the past two decades.
- 3) Temporal variation is stronger in precipitation than in water vapor, which results to the positive (negative) trend of recycling rate in the high (low) precipitation region.

References:

Li, L., X. Jiang, M. Chahine, E. Olsen, E. Fetzer, L. Chen, and Y. Yung, 2011: Recycling rate of atmospheric moisture over the past two decades (1988-2009), Environmental Research Letters, doi: 10.1088/1748-9326/6/3/034017.

Thank you!